AUTOMATIC CONTROL OF ELECTRIC FLAT IRONS—ALSO PROPOSED METHODS

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PREFACE

There are many flat irons on the market at the present writing, and with one or two exceptions, *these irons are all designed to operate at a single temperature, which necessarily makes them very inefficient. To iron cloth at the highest degree of efficiency and with the least danger of scorching, it becomes necessary to have an iron, the temperature of which, can be readily adjusted to any temperature (within limits) depending on the weight of the material and the amount of moisture it contains. Because of this void created by our lack of a successfully efficient flat iron, we the undersigned have undertaken the task of evolving a "multiple heat" flat iron that will not only combine simplicity and cheapness of construction with a high degree of efficiency, but also the non-liability to develop trouble, a detail which has been overlooked by the designers of "multiple heat irons".

Grateful acknowledgements are made of the great readiness with which Mr. E. J. Carrol, American Laundry Machinery Co., Mr. Ross P. Blodgett, Edison

Electric Appliance Co., and others, have answered inquiries with reference to what their respective companies have accomplished along the production of electric flat irons. For the great patience and considerable time spent by Miss Ford Librarian, Armour Institute of Technology, in preparing for us a bibliography on the subject, we must also extend our thanks.

Signed: Rudolph Kuotek.
Joseph Newman.

* Note see Bibliography.

STATEMENT OF PROBLEM

There are many factors that enter into the design of electric flat irons, but as we are primarily concerned with temperature control, we will limit our discussion to the temperature factor. The single temperature flat iron is designed to operate at about 250° centigrade plus or minus about 25 degress. This temperature must be varied according to the thickness of the material, the character of the surface exposed and the amount of moisture present in the material.

The thickness of the material will determine the temperature. A very thin material will have a low heat capacity and therefore an iron placed upon it operating within the temperature range given above, may scorch it, whereas, a thicker material with greater heat capacity, would not scorch with this same temperature. As a rule, silks and cottons are ironed or pressed with very little moisture present, so that an iron can be relatively cooler to do the same work. In the case of wool and heavy goods of this nature, it is the general practice to

use a press cloth which is wet or covered with water and the pressing is largely done by steam passing through the weave of the goods. In this case, the iron must have a high heat in order to provide the necessary pressure to drive the steam through the goods.

To successfully meet the requirements enumerated above, it becomes necessary to device a means of regulating the quantity of heat generated by the iron. This device must be simple in construction, must not require an enlargement of the present proportions of the iron to any considerable extent, must not be costly and last but not of least importance, this device must be free from trouble and must be persistent in its actions.

STATEMENT OF WHAT HAS BEEN DONE

Little has been accomplished in the field of automatic electric flat irons of the type mentioned; no doubt, there has been many unsuccessful attempts to produce such an iron, all of which attempts we will never learn about. There are only two irons of the automatic type that have seemed to live through the experimental stage of development and that are apparently commercially successful (so far as the manufacturers themselves are concerned) they are the "A-Best-O" manufactured by the Dover Manufacturing Company of Dover, Ohio and the "Reimers Regulator Flat Iron" manufactured by the Reimers Manufacturing Company of New York City, New York, which irons we will presently describe.

The Dover "A-Best-O" Automatic Control Flat Iron (See Electrical Review and Western Electrician, Aug. 16, 1913).

The Dover Manufacturing Company, as a result of its experience in manufacturing flat irons of all kinds, saw a need for an iron of the type stated above and set about to develop an electric iron with

No. 6½ A-BEST-O ELECTRIC IRON WITH AUTOMATIC HEAT CONTROL

The iron found in the dealer's own home—the salesman's own home. Why? Confidence plus the wonderful thermostatic control—which has been successfully applied only to the A-Best-O.

The heating current is automatically admitted and shut off. The iron is never too hot or too cold. The black thumbscrew does the trick—turning to the right gives more heat—to the left less.

Fig. 1.

the automatic feature referred to. After prolonged experiments and repeated tests, an iron of this kind has been placed on the market, which the manufacturers claim can be absolutely depended on to maintain its temperature at the points set when the simple directions for its use are followed. A general view of this iron is shown in Fig. 1. The resistance element is embedded in a very refractory insulating material. One of the terminal wires of the element connects directly to the binding screw to which one side of the cord circuit is connected. The other wire connects to the middle binding screw and between the latter and the right hand post (the other end of the cord circuit) are connected in parallel, the thermostatic cut out and condenser.

The thermostatic cut out consists of a rigid steel bar to whose ends if firmly secured a bowed bar made of a special alloy with a high coefficient of expansion. At its middle this bar carries a contact with a platinum point. Above this is a relatively fixed but adjustable co-operating contact with a platinum point. When the iron heats, the expansion

bar bends more and more until at a definite temperature depending on the adjustment, the contacts separate and the circuit is broken. Since the condenser is in parallel with this cut out, no troublesome arc is formed between the platinum points. As the iron cools a little, the thermostatic bar bends back bringing the contacts together again and restoring the heating circuit. The action of this bar is so sensitive and automatic that the device will maintain the temperature of the iron within five degrees of the temperature at which it was set.

In order to permit control of the temperature an adjustable regulator is provided. This consists of an outside spring to which is fastened an insulated thumb screw. This engages an insulated cap which rests on the inside temperature spring that carries the upper contact point. By varying the tension on this spring it is possible to regulate the temperature of the iron at will between the limits of 200 and 600 degrees Fahrenheit, thus readily adapting the iron to the varying requirements of thin, medium and thick fabrics.

It is difficult for the authors to describe the "Reimers Regulator Flat Iron" due to the fact that it is impossible to obtain any information pertaining to this iron.

OUR THERMOSTATIC METHODS

After a thorough examination of the United States Patent Reports covering a period of fifteen years from 1905 to 1920 to determine just what has been accomplished in the field of our endeavor and also to avoid repeating the efforts of others, we decided upon two possible means of fulfilling our aim namely; (1) by the "non-expansive link mechanism" and (2) by the "thermostatic strip", both of which we shall presently discuss. Our claims, two in number, as to the originality of these ideas are (1) we claim that no person has employed the "non-expansive link mechanism" (see Fig. 2) and (2) although the "thermostatic strip" is used in other irons, our claim is based upon the originality of the quick make and break mechanism employed in conjunction with the strip.

THE NON-EXPANSIVE LINK MECHANISM

The non-expansive link mechanism consists of a number of links of invar (a nickel steel alloy, coefficient of expansion 0.000001 cm. per cm. per degree centigrade), arranged as in Fig. 3. Fk, gk,

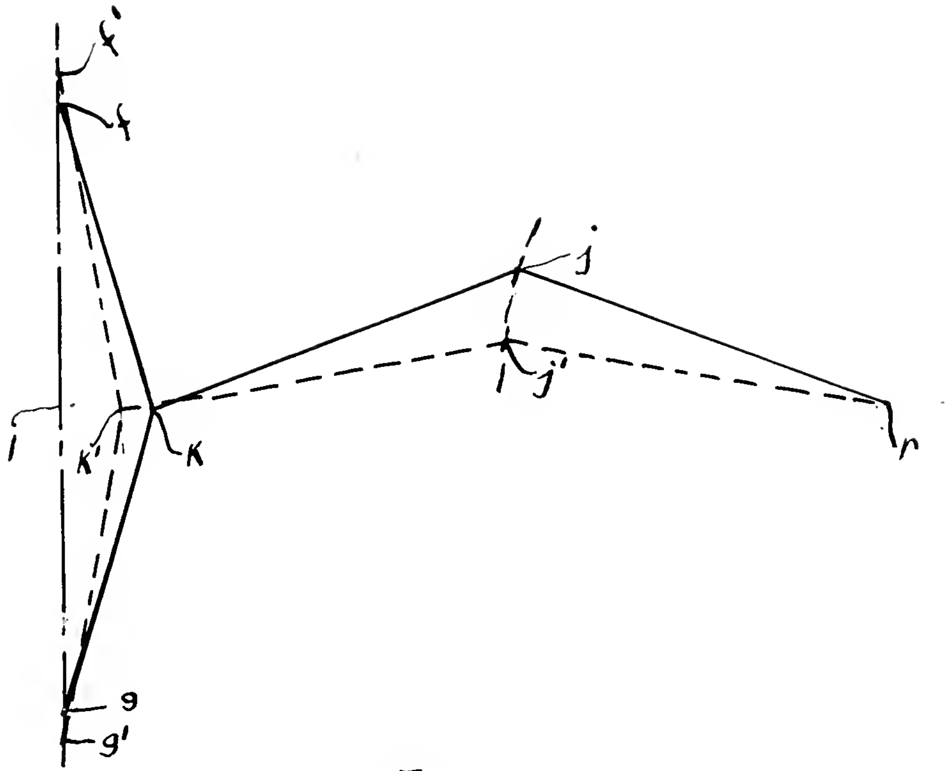

Fig. 2.

kj, and jh are links of invar pinned to base C at f, g and h and fastened to each other at k and j. This arrangement combines the longitudinal and transverse expansion of the base into a rectilinear movement of the point j, along the dotted line as indicated in Fig. 2.

That the movement of j may be a maximum, it becomes necessary to determine the proper length of the links. Referring to Fig. 2, let fkg represent links fk and gk as in Fig. 3; let the points f and g move along yy as would be in Fig. 2 where the temperature of the base changed. (The best length of the links depend only upon the movement of the points f and g in the transverse direction and not upon the movement longitudinally; therefore, we may neglect the longitudinal expansion so far as the length of the links is concerned.

Let f'k'g' be the final position with

f'f = gg'; fk = gk and no change in the length of the links.

Then $lk = \sqrt{fk^2 + lf^2}$; $lk' = \sqrt{f'k'^2 + (lf + ff')^2}$

or $kk' = \sqrt{fk^2 + lf^2} - \sqrt{f'k'^2 + (lf + ff')^2}$

From which we obtain for largest k'k that f'k' is equal to lf + f'f = lf'.

Which expressed in words is, "For the greatest movement of the point k the links fk and gk must each be equal in length to the distance between the points at which they are fastened to the base plus half of the total expansion of the base along the line connecting these points.

Let us now focus our attention on the movement of the point j or Fig. 2; the movement of k with respect to a transverse axis through r is kk'-b where b is the longitudinal expansion of the base C.

From the previous mathematics,

$$\text{Length of } kj = jr = \frac{kr}{2} + \frac{kk' + b}{2}$$

movement of j to j is

$$\sqrt{\left(\frac{kr}{2} + \frac{kk' + b}{2}\right)^2 - \frac{kr}{2}^{\,2}} = jj'.$$

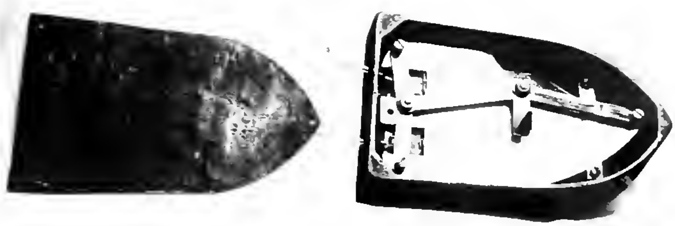

Fig. 3.

Fig. 4.

CONSTRUCTION

There being no irons available that would afford ample space within to house our mechanism, we constructed two irons having the dimensions as shown in Fig. 3.

With the thoughts of using the base of the iron as the element C of the mechanism, we set about to determine whether or not the movement of j with this arrangement would be sufficiently large enough as to be of practical use. A careful consideration of Fig. 5 will show that we have provided three projections which correspond to the points fg and r of Fig. 2. From Fig. 3, we have

$$fg = 3'' = 7.62 \text{ cm. and } lr = 5.8'' = 14.75 \text{ cm.}$$

The coefficient of expansion of cast iron is 10.2 10 cm. per cm. per degree centigrade. The maximum rise in temperature of the iron is 430 F or 220 C. The total longitudinal expansion of the base is equal to

$$14.75 \times 220 \times 10.2 \times 10^{-6} = 0.033 \text{ cm.}$$

Total transverse expansion of base is equal to

$$7.62 \times 220 \times 10.2 \times 10 = .017 \text{ cm.}$$

fk = 3.81-.0085 = 3.8185 cm. and the movement of k = 3.8185 - 3.81 = .254 cm. total movement of k = .254 - .033 = 287 cm. Then

$$kj = \frac{14.75 - .287}{2} - \frac{.254}{2} = 7.3195 \text{ cm.}$$

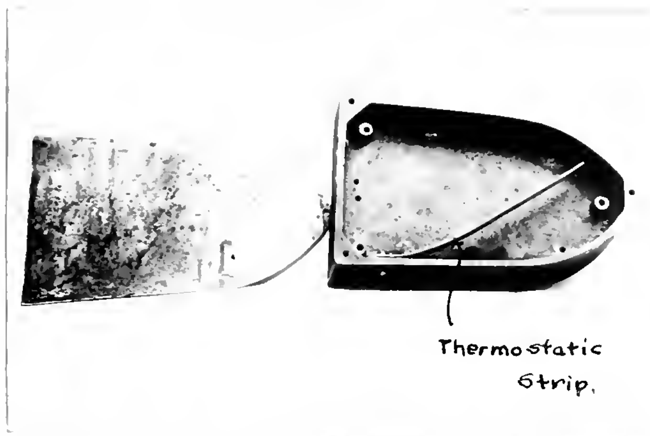

Fig. 5.

Therefore the movement of j = 7.3195 - 7.248 = 1.02 cm. The fact that we obtained by calculation a large movement of 1.02 cm. for the point j, lead us to mount links in the iron Fig. 5 and determine experimentally the amount of movement of j. Our experimental results did not fulfill our expectations for there was no appreciable movement of j, from its zero position when the iron was heated to 500° C. From the above, we suspected that invar has an appreciable coefficient of expansion at this high temperature,and that this coefficient would perhaps be equal to the coefficient of cast iron at 500° F which therefore would make the actual movement of j very small. We inquired at the Bureau of Standards for information concerning this coefficient and the reply, (which verified our suspicion) was, the coefficient of expansion of invar is usually quite small over the range 40° to 80° C; say 0.000001 cm. per cm. per degree centigrade. The coefficient increases with temperature and at 300° C. may reach a value near that of steel, say .0000113 cm. per degree centigrade.

We constructed an aluminum base and mounted the

same links upon it. The base was subject to temperature changes, from room temperature to 500° F, and back again to room temperature, to determine the motion and persistency. Our conclusion is that the motion is big enough and that the aluminum is persistent in its action after being heated to 500° F.

THERMOSTATIC METAL

It is a well known fact that if two pieces of metal of different coefficients of expansion are subjected to the same temperature difference, one will expand to a greater extent than the other. Suppose these two strips of metal are placed side by side and in some way jointed, it is readily seen that the one with the greater coefficient will expand the further and thus lend to produce a distortion as the resultant of the varying abilities of the metals to expand.

When a piece of thermostatic metal is subjected to a change in temperature, it becomes distorted from its original shape. This distortion is a feature which can be utilized to perform many varied duties in the control and regulation of devices sensitive to temperature. During the process of distortion, a considerable amount of energy is made available in the form of useful work, which can be utilized in the operation of both mechanical and electrical devices.

The thermostatic metal used by the authors is a bimetallic strip made by permanently welding thruout their length, the two metals, invar steel and

brass. Invar steel has a coefficient of expansion of 4×10^{-7} cm. per degree Fahrenheit and brass has a coefficient of 9.8×10^{-6}, approximately 25 times the coefficient of invar. It is readily understood that when this bonded combination is subjected to a change in temperature the differential expansion which occurs along the entire length, causes a perfectly definite and regular distortion which approximates a curve of an arc of a circle when the effective increase in temperature is removed and the metal returns to its original temperature, the distortion is likewise removed and the metal resumes its original shape, i.e., a straight piece. The manufacturers claim for this metal a constancy of operation for temperature of 500° Fahrenheit.

FORMULA TO BE USED WITH WILCO STRIP

NOTATION

d = deflection in inches

t = thickness in inches

l = length in inches

w = width in inches

p = pull in ounces

$T - T$ = change in temperature ^{o}F.

$$d = \frac{(T - T)l}{1.3\ 10\ t}$$

$$p = \frac{6.74\ 10\ dwt}{l}$$

$$p = \frac{518t\ \ (T - T)w}{l}$$

It is well to note here that the above formula for deflection (d) does not include the variable of width. For all practical cases this is true, but in the event that very wide pieces of the metal are used, the effect of cross bending is felt, i.e., the strip tends to bend in two directions, first along the axis and second at right angles to the axis. This effect tends to decrease the activity of the metal.

OUR QUICK MAKE AND BREAK MECHANISM

This device is illustrated in Fig. 8; it consists of a fiber base A, on which is mounted the L shaped arm B (free to rotate about the screw C); brass blocks D and E watch springs F and G and the spiral spring H. The thermostatic device (see Fig.8) rests against the adjusting screw J. Spring G is insulated from block D.

In the position of arm L as shown in Fig. 8, the circuit through coil L (coil K is permanently connected across the line) is from coil L through block D, through spring F thence through spring G back to the line. On being heated, the thermostatic mechanism within the iron forces arm B in the direction indicated by dotted arrow, thus pin 1 is forced against spring F and when F has assumed the position indicated by F' (Fig. 7) it suddenly snaps into the position F" and the circuit through coil L is broken, the iron is thereby permitted to cool the thermostatic device thereby more in the opposite direction, the lever B is forced by the spiral spring H to follow this movement and when F reaches the position indicat-

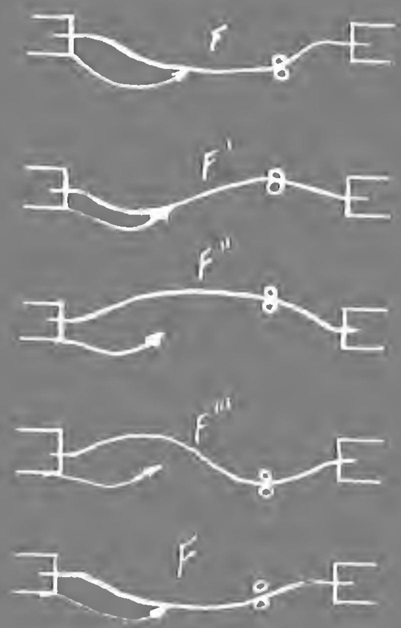

Fig. 7.

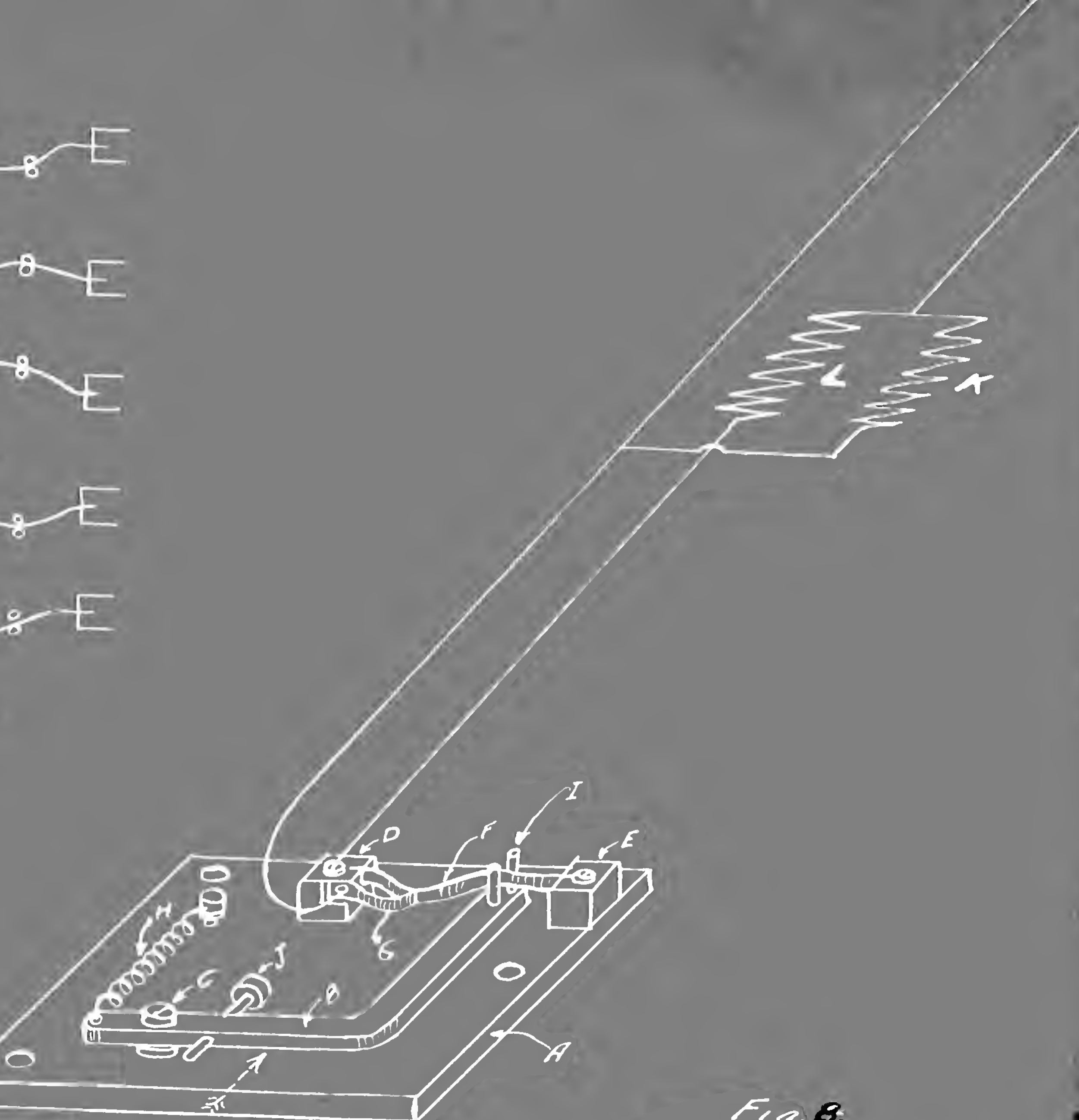

Fig. 8.

ed by F" (Fig. 7) it suddenly snaps into the position F and the circuit through coil L is closed. The spring G is adjusted so that it just leaves contact with F when F has reached the position F. By means of the adjusting screw J, the position of spring F with respect to the center position F' (See Fig. 7) may be changed and thus the temperature of the iron may be controlled. This mechanism has been constructed as shown in Fig. 6.

Fig. 6.

PROPOSED METHODS

During the early stages of our work and before we fully understood what was necessary to produce successful thermostatic control, we were lead to conclude from what information was available to us at the time, that there existed a difficulty of obtaining a metal that would operate with persistency after being subjected to the intense heat within the iron. With this conclusion in mind, we spent considerable time devising means of overcoming this difficulty, which means we had intended to develop (if time permitted) or, to propose as possible means. As time progressed, we determined by experiment (see Experimental Methods) that e.g. thermostatic metal and aluminum will perform persistently at 500° Fahrenheit (the temperature within an iron) and we therefore concluded that the thermostatic strip is entirely satisfactory. The difficulty lies not in any trouble to obtain persistent metals but in the difficulty to eliminate sparking at the contact points. The most feasible way of doing away with this arcing, is by means of a "quick make and break" mechanism; but as

time prevents us from devising other means of obtaining the same result, we must leave unfinished that which is suggested by "Also Proposed Method".

CONCLUSION

The assembled iron Fig. 6, was tested to determine whether or not the "quick-make-and-break" mechanism would work satisfactorily; and, it was found that the temperature change within the iron between the time interval of the opening and closing of the circuit by the "quick make and break" mechanism was approximately seventy-five degrees Fahrenheit,which is, of course, poor temperature regulation. This temperature difference can be considerably reduced by making all parts smaller by machining them accurately, by substituting tempered bronze for the watch springs (the electrical resistance of the steel springs are quite high) and by using platinum contact points.

The "quick make-and-break" mechanism has been found to work more satisfactorily with the thermostatic strip due to the fact that the motion necessary was greater.

Since the completion of the two irons heretofore mentioned, we have received from the Dover Electric Company, an "A-Best-O" Electric Flat Iron which is described in detail in an earlier part of this

paper; and after noting the simplicity of construction and the almost arcless temperature control device, we have conclused that although further development of our device with the modifications mentioned above will result in a fruitful conclusion, the cost to manufacture, as compared to the cost of the "A-Best-O", will be excessive because of the great amount of machine work required to produce accurately fitting parts; therefore, our irons will not be as readily marketable as the "A-Best-O". Due to our eagerness to obtain a means of producing arcless current interruptions, we have overlooked this element of "cost", which element must be always taken into consideration in the development of any successful device.

A test was made on the "A-Best-O" flat iron, but in vain. The results that we obtained were unsatisfactory as to temperature regulation. The trouble seems to be that the thermostatic strip is too small to be sensitive.

THERMOSTATIC CONTROL OF ELECTRIC IRONS

Automatic electric iron (F. D. Burr)
Electrical Review and
Western Electrician 66:485 March 13, 1915.

Reimers regulator flat iron,
Electrical Review and
Western Electrician 66:86 January 8, 1916.

Improved Dover electric flat irons,
Electrical review and
Western Electrician 68:691-2 April 15, 1916.

Temperature variations cause new "Thermostatic Metal"
to control or regulate devices.
Electrical Review 71:39-40 July 7, 1917.

Electric iron with heat tensified at point,
Electrical World 66:1218 Nov. 27, 1915.

Electric irons with resistors embedded in alumina.
Electrical World 67:729 March 25, 1916.

Electric iron.
Electrical World 70:1178 Dec. 15, 1917.

Evenly heated electric iron.
Electrical World 72:427 Aug. 31, 1918.

Flat irons and other appliances.
General Electric Review 22:193-4 March, 1919.

Thermostatic metal developed by General Electric
Company to control appliances by heat or cold.
Marine Engineering 23:17-18 January, 1918.

Arcing caused short-circuit.
Power 44:858 Dec. 19, 1916.

Thermostats: various types and methods of application.
(W.N.Ray & J. Reilly)
Scientific American
Supplement 86:198-9 Sept. 28, 1918.